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WORLD MARITIME UNIVERSITY
Malmö, Sweden

**MANAGING OPTIMUM WORKLOAD THROUGH
TERMINAL APPOINTMENT SYSTEM (TAS)**

Case of Jakarta International Container Terminal

By

Usman Saroni
Indonesia

A dissertation submitted to the World Maritime University in partial
fulfillment of the requirements for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS

(SHIPPING MANAGEMENT AND LOGISTIC)

2015

Declaration

I certify that all the material in this dissertation that is not my work has been identified and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my personal views and are not necessarily endorsed by the University.

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Co-assessor: *
Institution/organization:

Acknowledgement

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Usman Saroni

October 2015

Abstract

Title of Dissertation: **Optimization of Container Terminal through Terminal Appointment System (TAS): Managing optimum workload of container terminal operation, case of Jakarta International Container Terminal (JICT)**

Degree: MSc

The Dissertation is a study of optimizing terminal through Terminal Appointment System (TAS), comparing the impact of unscheduled truck arrival with regulated truck arrival to the optimization process. A brief look is taken at present growth in container business. The rapid growth of world container trade, especially in Asia brings economic potentials for the countries and also challenges for container terminals. Capacity limitation in accommodating the trade growth forces the terminal to optimize their existing equipment and facilities. The evaluation of the existing performance of each component of the terminal operation, covering quay, yard and gate operation, is a starting point to identify the crucial problem in the optimization process. Many terminals implement Terminal Appointment System (TAS) to optimize their operation. This dissertation discuss the benefit and the impact of TAS implementation to the container terminal operation. The concluding chapter examines the impact of TAS solution in optimizing terminal operation. Some recommendations are made concerning the implementation of TAS.

KEYWORDS:

Terminal Appointment System, Container, Optimization, Appointment, Quantitative Analysis, Queuing

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CHAPTER 1. INTRODUCTION

1.1. Background

World Trade seaborne trade volumes are forecasted grow by 4.2% in 2014. East–West trade and intra-Asian trade are driver factors of global trade with volumes projected gains by 6 per cent and 7.7 per cent respectively. China and ASEAN (The Association of Southeast Asian Nations) countries play as main players in the intra-Asian trade, with total trade reach \$500 billion in 2015 (Review of Maritime Transport, 2014, p. 23).

Even though China is still the biggest economy of emerging market, ASEAN (The Association of Southeast Asian Nations) countries have an immense potential to be a new major global hub of manufacturing and trade. ASEAN encompasses Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. ASEAN countries combined GDP reached \$2.4 trillion in 2013, and it is projected to be the fourth-largest economy by 2050. The GDP was generated mainly by the service sector and industry sector that accounted for more than 80% of total GDP (ASEAN, 2014).

Industrialization in ASEAN is growing along with the availability of cheaper labor force and growing number of consuming class. Inhabited by 630 million populations attract companies to relocate their business base to ASEAN to get more competitive production cost and closer to the potential market. Government of ASEAN countries are competing to provide infrastructures and facilities to invite more industry to invest in their country.

The success of ASEAN countries in gaining the trade growth in the region differs one to the others. Even though the size of the market and the availability of natural resources are significant in attracting industries yet the ability of government in providing trade

facilities is imminent in building trade competitiveness. The key factor of commerce facilities are infrastructures and business easiness. These are components where World Bank evaluates the trade competitiveness of a country.

An obvious comparison, between Singapore and Indonesia, reflects how trade infrastructures influence the quality of trade competitiveness. In 2014, Singapore with population is only 5.4 million generate 783,265.5 Million USD while Indonesia with 250 million population only reached 369,180.5 million USD (ASEAN, 2014).

Indonesia is a valid case study of how infrastructures become barriers to optimizing resources and gaining the bigger opportunities in the trade. Even though Indonesia has the largest market among ASEAN countries and has potential natural resources, nevertheless it has weak competitiveness in the international trade. World Bank report, LPI 2014 (Logistic Performance Index), reflects that Indonesia rank for international shipment and infrastructure are still lower than the average of ASEAN countries.

Port capacity limitation as one of the key components of international trade is still a significant challenge in Indonesia. Shortness of capacity has decelerated the effort to draw up and realize the national and regional economic potentials (Bahagia, Sandee, and Meeuws, 2013, p. 1). Owing to limitation of capacity, some volume of trade should be diverted to Singapore for transit, before entering Indonesia port. The other cargo that succeeded in entering Indonesia port may face challenging logistical problems, such as congestion, longer turn round time, traffic congestion, and delays in delivery and eventually leads to high cost of logistic.

Many of Indonesia's main ports are already taxed. Technical work undertaken for the National Ports Master Plan estimated that the ports of Belawan, Tanjung Emas, Tanjung Perak, Tanjung Priok are each operating at around 90% of actual capacity. While the

Ports of Pekanbaru and Samarinda, are each operating at around 80% of actual capacity (Law, 2012, p. 13).

Tanjung Priok is the densest among Indonesia's Port. Since the ASEAN-China Free Trade Agreement came into effect in January 2010, Tanjung Priok, the country's main trade gateway, has seen constant congestion. Tanjung Priok was intended to handle 5m TEUs, but it managed 5.6m TEUs in 2011 and 6.2m TEUs in 2012 (Oxford, 2014).

As the country's main gateway that is handling approximately 65.5% of the external trade volumes of Indonesia. Tanjung Priok Port is stressed to serve the growth of commerce in a limited infrastructure. The traffic jams in Greater Jakarta are happening and hindering investment. Tanjung Priok – the country's main international sea-freight gateway – is close to full capacity (Henry Sandee, 2011). As the result of under-capacity and operational inefficiencies, there is high congestion in and around the port, with frequent queues before the gates of several kilometers long (OECD, 2014).

Container throughput at Tanjung Priok Port is predicted to increase by 65.5% in the next four years to grasp 10.3m TEUs in 2017. However, without meaningful investments in port capacity expansion as well as an improvement of its infrastructure, it is tough to see how Tanjung Priok could manage such an expansion (Oxford Business, 2014).

The Indonesian government does realize this condition and trying to build more port infrastructures. Through the Master Plan for Acceleration and Expansion of Indonesia's Economic Development Program, the Government of Indonesia has shown its appreciation of the need investment in the improvement of the logistics system. The investment's focus is not just on hard infrastructure, but also the so-called soft infrastructure; more conducive regulations to expedite trade and transport (Bahagia, Sandee, and Meeuws, 2013, p. 7).

Nevertheless, building infrastructure requires enormous investment and lengthy periods of time. On the other side, problems arise every day, opportunities and competitions are continuing. Waiting for improvement or development of new infrastructures definitely will cost more complaints and loss of opportunity. Limitation of capacity is forcing terminal to optimize their existing resources to dealing with trade growth. Therefore, some additional initiatives and strategies are formulated to adapt to the challenges.

Planning is the key point in the optimization process. Terminal container manager should plan the operation thoroughly and prevent any idle on facilities and equipment. An hourly basis operation planning will help terminal to mitigate a big deviation in operational level. A Continuous monitoring and evaluation are required to make sure the facilities and equipment are working effectively and efficiently.

Container terminal operation consists of three main components, quay, yard and gate operation, a good operation planning should integrate all area of operation. To plan quay operation is relatively easy as quay operation serves the container vessels with fixed and regular schedules. Nevertheless, to plan yard operation is more complex as yard operation serves quay and gate operation simultaneously. The complexities of yard operation even more when the arrivals of external trucks at the gate are unscheduled.

Unscheduled time of arrival of the truck create uncertainty in terminal operation. To solve the problem some terminals regulate the arrival of the trucks by providing particular service window time where the number and time of truck arrivals are planned. Before the truck visit the terminal, truck should book the terminal service through a system, known as Terminal Appointment System (TAS), by informing their arrival plan to terminal. By having this information, terminal can plan their equipment and other resources properly to improve their operational optimization.

1.2. Objectives

Following the background information mentioned above, the dissertation seeks to explain optimization strategies in container terminal dealing with yard capacity limitation. The discussion is focused to gate operation management in controlling the truck arrival through the implementation of Terminal Appointment System (TAS). Therefore, this dissertation will cover the following topics:

- The general concept of operations in a container terminal through a literature review. The discussion will incorporate the basic concept, challenges, and operational strategies in the optimization process.
- Introducing TAS by reviewing academic literature and business practices covering general references to technical aspects of implementing truck arrival management, covering procedures, equipment, and system requirement
- Problem identification in a container terminal dealing with capacity limitation.
- Data from Jakarta International Container Terminal (JICT) are used as a study case.
- Measuring the impact of unscheduled truck arrival to the truck queue.
- Evaluating on a TAS solution in above problem.

The dissertation contributes to the current knowledge base of container terminal operations management and help container managers in their daily operations in the planning process.

1.3. Scope of Work and Methodology

Optimization is a daily and continuous objective in container terminal operations. Managers are required to control and monitor the progress of operations highly optimized. Therefore, a simple and practical approach to analyzing the situation is required to formulate an operational decision that is easy to follow and easy to communicate with their team members.

Therefore, this dissertation will use a quantitative method to analyze the data and identify the operational problems and their impacts, and to provide an optimization solution. The data derives from historical data equipment transaction of JICT. It comprises of quay cranes (QC), Rubber Tired Gantry Crane (RTGC), Reach Stacker (RS), and gate transaction is from January 2013-June 2013. Researcher

Furthermore, the MS Excel will be used, to process the data by implementing the quantitative methodology. Linear Programing (LP) will help to identify the optimum capacity of the terminal equipment by involving the linear optimization of a linear objective function, subject to linear equality and inequality constraints. Fluid Approximation (FA) model illustrates the situation of the terminal in serving the truck by considering truck queues as a fluid flowing into a reservoir, which represents the ability of terminal in handling the trucks. FA model estimates the number of the truck line through a single nonlinear differential.

To support the implementation of solution, researcher provides general guidance and technical aspect related to TAS. The technical aspect derives from the best practice of some terminals that are implementing TAS, such as Long Beach Container Terminal, Sydney Container Terminal, and Hong Kong International Container Terminal.

1.4. Structure and organization

The structure of dissertation comprises of six chapters with the following order:

Chapter I presents the background and main objective of the thesis by briefly describing its overall concept and methodology.

Chapter II evaluates some literature related to the general concept of container terminal operation and optimization strategies on three component of the terminal operation,

covering quay, yard, and gate operation. Introduce TAS as a strategy to manage the container terminal workload.

Chapter III identifies a problem in optimizing container terminal operation by evaluating the three components of operation. BCG matrix model will be used to define the problem and case study of JICT will be presented for further discussion.

Chapter IV analyzes the problem and measures the impact on terminal service without implementation of TAS. A simple linear programming will identify the optimum operational limit. Furthermore, the queuing theory will simulate existing operational problem resulted by exceeding the operational optimum limit.

Chapter V evaluates the TAS solution in solving the problem. The queuing simulation will be repeated with TAS implementation scenario. Furthermore, the result of the new simulation will be compared with the previous simulation to evaluate the effectiveness of TAS solution.

Chapter VI concludes by summarizing the impact of unscheduled truck arrival. Also, propose the implementation of TAS as the solution to optimize the existing infrastructure.

CHAPTER 2. LITERATURE REVIEW

2.1. Introduction

Optimization is a central topic in container terminal operations. Limitation of resources such as land, facilities, equipment, manning, and financing are the driver factors of a container terminal in pursuing the most optimum and efficient operations. Moreover, competition among container port for better and cheaper customer services leave terminal operations no option but optimizing their service.

There are several approaches in optimizing container terminal operations. Some approaches are from an engineering aspect and some other from an operational aspect. Engineering perspectives try to optimize the terminal operations by improving the quality of materials, design, information and technology of the equipment. The other approach focuses on how to utilize equipment and facilities to gain an optimum operational result. This literature review will only discuss the research related to the operational strategy by identifying some optimization tactics and considering the impact to Key Performance Indicators (KPI) of each part of operations.

As shown in Figure 1, the process of import container movement starts from the discharging activity of a vessel by quay crane at Quay site. Then the transfer is taking place to transporter equipment, such as Automated Guided Vehicles (AGV), straddle carrier, and trucks to the yard for temporary storage. Finally, containers are moved to a gate area to be loaded by Rail Mounted Gantry (RMG) onto train or trucks for the further delivery process to customers. The process is the opposite for the export container (Bichou, 2014, p. 137).

Three groups of operation work as a system in high dependency. A good terminal operation performance will only possible when all components work collectively and support each other. Consequently, each group requires support from the others to

achieve their individual KPI to improve the KPI of the whole operation. The quay operation KPI depends on backing from yard operation. At the same time yard operation depends on the support of the gate service.

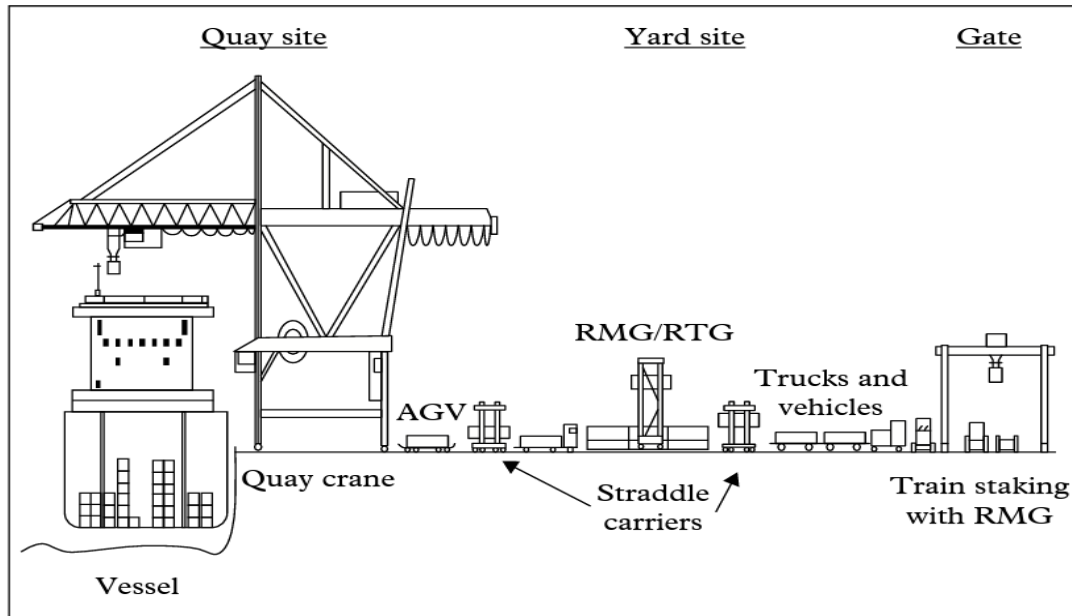


Figure 1 Container Terminal Operation Process (Bichou, 2014, p. 137)

It is critical to optimize the individual performance of each part of the operation to achieve an integrated performance of the whole system. Nevertheless, focusing KPI to only one part of the system may lead to imbalance workload at the other parts, and consequently the entire system will work under optimum level. Therefore, the optimization process has to be integrated to avoid sub-optimization in a particular area (Böse, 2011, p. 91)

2.2. Quay Operation

Quay operations are activities on quayside area where terminal performs discharge and loading containers from and onto the vessel. In a modern container terminal discharge and loading are performed by Quay Cranes (QC). However in an exceptional case the terminal could use other special equipment to handle the containers, such as floating

cranes, ships cranes or other mobile cranes. Usually, additional equipment only handles special cargo such as over dimension cargo, or overweight cargo that is the weight beyond terminal crane capacity. This thesis will only measure the performance of QC as a main KPI of quay operation.

The main KPI of quay operations is QC rate. It represents the capability of a terminal in handling container to serve shipping company, as their primary customer. Container terminal puts a high priority in pursuing a higher QC rate. It does not merely reflect the efficiency of terminal operation, better service to clients, but also a prestige in completion among container terminals.

QC rate calculates the average performance per hour of a QC in handling containers in a full cycle. The QC cycle has three steps, firstly lift on or lift-off container on the vessel, the subsequent transfer to pier side, and finally lift on or lift-off container on transfer vehicle/truck. Technically performance of QC could reach 50-60 boxes/hour, nevertheless, in operational the average performance is 22-30 boxes/h (Günther and Kim, 2005, p. 8).

There is a gap 50% between average functional and technical specification of cranes. Researchers have been trying to apply the various methodologies to improve the performance of QC. The objective of the thesis is to upgrade crane productivity closer to its maximum capacity. There are two well-known strategies to improve QC performance, namely dual cycle and truck pooling.

Crane Dual Cycle

Double cycling is the method of using these “empty” moves to carry a container, thus causing the crane more productive, and reducing turn-around time. When discharging and loading a ship, most cranes consume only half of their moves carrying a container.

During unloading, the crane is empty when running to the vessel. During loading, the crane is empty when returning to the dock (Goodchild and Daganzo, 2006, p. 473)

As illustrated in Figure 2(a), one cycle crane operation produces single loading or single discharge for each movement (Zhang and Kim, 2009, p. 980). Since there is an empty movement in every cycle, crane should perform two set of the cycle to handle two containers. Assuming one cycle is 5 minutes, it takes 10 minutes to handle two containers. In the Figure 2(b), the dual cycle crane does not have an empty movement. Crane transfer is loading-container while traveling to the vessel, subsequently carrying discharging-container when returning to the quay deck. With the same assumption previously, the crane will be able to handle two containers within one cycle and only takes 5 minutes of the time.

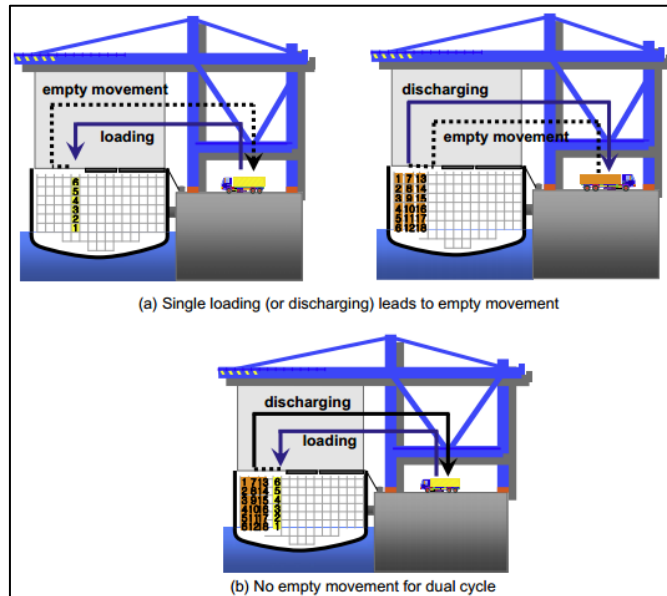


Figure 2 Comparing the Single Cycle and Dual Cycle QC Movement
(Zhang, 2009, p. 980)

Goodchild and Daganzo (2006, p. 476) explain that while the dual cycle is appropriate for handling containers in the same row on the ship, nevertheless it is not practical for handling containers in different rows. The reason is that since cranes should move laterally between rows hence it consumes additional time. Furthermore, the dual cycle involves substantial operation planning of discharge and loading simultaneously, therefore, requiring truck scheduling to make sure double cycle run smoothly.

Transporter Pooling

Almost similar to dual crane cycle, transporter pooling aims to allow carriers (trucks/AGVs) gain two containers in one cycle. In the single-cycle mode, the vehicles dedicated serve only one crane. According to the crane's cycle, they either serve for discharged containers from the quay to the yard or export containers from the yard to the crane (Günther, 2005, p. 26).

In pooling mode, the transport vehicles serve several cranes that are in the loading or unloading process. After the transporter delivers the export container from the yard to the vessel, it does not return to the yard directly without carrying the container. Instead, they pick up another import container from another crane that discharges the import container. Transporter pooling optimizes both transport vehicles and also optimizes cranes. Transporters have an opportunity to carry containers during their travel going and back to pier side while cranes have a larger number of transport vehicles supporting its discharge or loading operation. Pooling mode makes transporter assignment more flexible and dynamic, hence reducing the risk of idle time.

2.3. Yard Operation

Container yard occupies the largest area of the terminal. In general, a container yard typically takes up about 60–70% of the total terminal area. It is primarily used to stack containers before subsequent transfer to a vessel for export container or transfer to the

consignee for container import (Lun, Lai, and Cheng, 2010, p. 184). The container yard is the most complex part of a container terminal. Yard operation serves the quay operation by receiving import containers and delivering export containers. At the same time yard serving gate operation by receiving export containers and delivering import containers. Also, yard operation performs additional movements inside, such as marshaling and shuffling.

Marshaling

Marshaling mainly is performed for internal needs of the terminal, as part of yard management strategy to improve operational efficiency. Marshaling activity relocates container from one block location to block further position in the same yard. Yu, Cheng, and Ting (2009, p. 2934) explain that there are two stages in the planning of the marshaling operation. Firstly, determining the optimal storage space for containers and secondly, optimizing the container moving plan. The objective to determine optimal storage space is to consolidate containers with the same destination from the scattered yard locations. Yard planning process will be easier when the containers are stacked according to the same category. Grouping also prevents yard cranes from moving too often between blocks during serving for the loading operation.

The second stage is optimizing the container moving plan. Furthermore, marshaling stage relocates containers, according to the next moving plan. The moving plan consists of the sequence of containers to be moved (in loading plan). Subsequently the containers are transferred and stacked in the opposite sequence of the loading plan. This stage of marshaling could significantly reduce shuffling during the loading operation.

Shuffling

Shuffling is relocating container within the same slot to collect the required container (Kawa and Golińska, 2015, p. 140). A shuffle is performed when the designated

container is under other containers. Shuffle in loading operation is caused by different loading sequence with stacking sequence. Shuffle in import delivery process is inevitable since terminal applies First Come-First Service. Hence, the delivery sequence is not following stacking sequence.

A container terminal with a local shipment for export loading and import delivery has a higher ratio of shuffling movement. In contrary, a container terminal with majority transshipment will have a little part of the shuffling activity since most of the transshipment containers have been planned prior discharge and loading. During discharge operations, transshipment containers will be stacked according to the sequence of the next loading operation. Hence shuffling will be less.

The shuffling movement also depends on yard density, or Yard Occupancy Ratio (YOR). YOR is the ratio between the numbers of TEUs of the container stacked in the yard over total TEUs of yard capacity of a terminal. In a high YOR situation, terminal stack containers in an upper tier (five up to six tiers containers in a slot) to maximize yard space. It increases the probability of shuffling since more containers may stay on top of the required container.

The number of shuffle moves that need to be performed by the yard equipment is supposed to be important in influencing yard productivity. Also, it reduces truck waiting times at the waterside and landside interfaces of the container yard. Container terminals consider shuffle as unproductive movements. Therefore, minimizing the number of shuffle moves could improve yard operation productivity. Finally, the accessibility of containers in the storage yard is defined by the average number of shuffle moves required to make a particular container available to take it out of the stack. This indicator is of great importance for the annual handling capacity of a container terminal. Fewer shuffle moves indicate a higher productivity of the terminal (Kempe, 2013, p. 35).

2.4. Gate Operation

Gate operation deals with outward freight forwarders. Two activities are engaged, namely export delivery and import receiving. Export delivery, where the freight forwarders bring in the containers to the yard to be loaded onto the vessel. Import receiving activity is where the freight forwarders receive containers from the yard or wharf and bring them to cargo owner (Esmer, 2008, p. 245).

Böse (2011, p. 315) explain the general process at the gate. Acting as a reception and delivery facility for the terminal, gate operation ensures every container and every truck enter and out terminal are validated and in a suitable order. Legality is the priority for the gate operation. Therefore, gate operation performs a set of checking before trucker in and out of the terminal. As seen in Figure 3, it starts with a pre-notice: (1) via Electronic Data Interchange (EDI). When the truck arrives at the terminal (2), it has to stop at a parking area outside the gate.

The driver has to get out for a personal check-in (3) for authorization and security purposes. The truck moves on to the in-gate after having registered at the interchange for the physical container check (4). The inspection validates the container and the seal number, the general condition, as well as any safety and security issues. If the vehicle does not bring any container, the driver could enter (5) the terminal without any further physical checking procedure. It takes sometimes to perform validation and inspection process. Therefore gate operations KPI measures the time spent by a truck at the gate before proceeding to the yard area. Gate with the manual method, involves paper administrations and ground staff to complete a transaction.

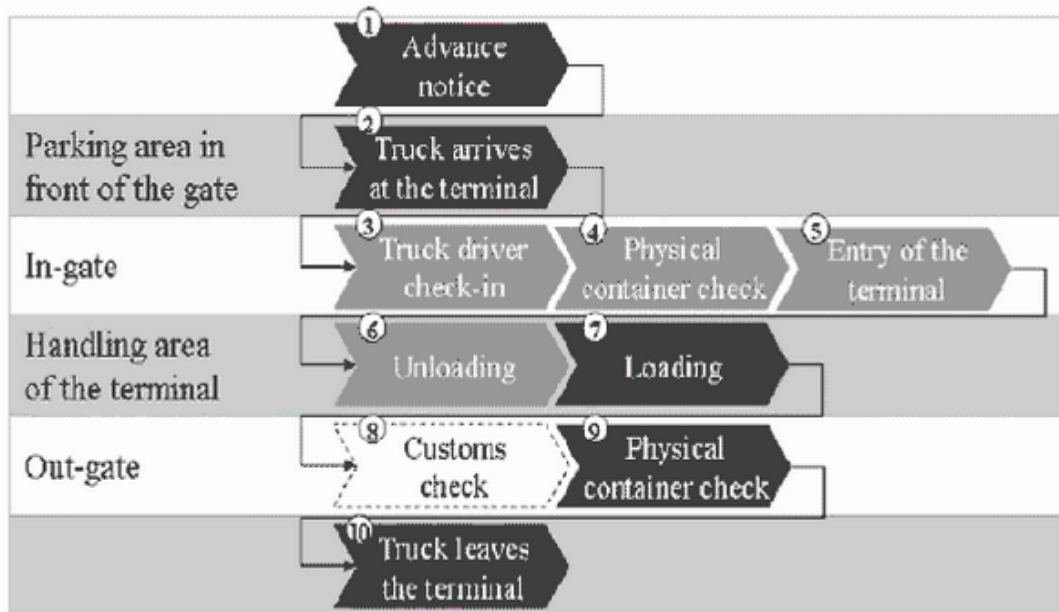


Figure 3 General Process of Truck Handling (Böse, 2011, p. 316)

Arriving at the handling area of the terminal, the inbound container has to be unloaded (6) before an outbound box could be taken (7). Then, customs checks (8) may be necessary at the terminal. Finally, a physical inspection (9) has to be carried out at the gate before the truck is allowed to leave the terminal (10) with a container. If the vehicle wants to depart without any cargo, no extra checking procedures are needed.

Dougherty (2010, p. 11) stated efficient gate operations are crucial to intermodal freight terminals. Their impact broadly influences the efficiency of the operations within the terminal and also extends to the road traffic on nearby freeways and access ramps. Too many trucks inside the terminal will create long queues inside the terminal and may disturb the operation. At the same time, too many trucks waiting outside the terminal will block the access road and trouble in the movement of public transportation. A precise measurement is necessary to keep the traffic at the optimum level, both in the terminal and access road.

Container terminal undertakes different operational strategies in managing gate operations. Some focus on traffic design, gate layout and the other focuses on traffic controlling. One of the most well-known studies is a procedure to handle the arrival of trucks through Terminal Appointment System (Merk, 2013, p. 141). Some research in the literature uses different terms for the same solution. Hayden and Brien (2008) use term Gate Appointment System (GAS) while Song (2012) uses Booking System (BS), Davies (2009) calls Vehicle Booking Systems (VBS) and Ltée., Conseil, and Consultants Ltd (2006) use (TAS) Terminal Appointment System. All term refers to the same system that regulates the arrival of the truck. In this thesis, (TAS) Terminal Appointment System is used to emphasize that this system is beneficial not only for gate operation but also for the whole terminal operations.

2.4. Terminal Appointment System (TAS)

Apart from the different literature regarding TAS, container terminals also use a different name for the system. Table 1 shows container terminal or port that has been implementing TAS with a different name.

No	Container Terminal Name	Country	System Name
1	Port of Los Angeles/Long Beach	USA	Appointment System
2	Sydney International Container Terminals	Australia	Truck Appointment System
3	Haropa Port	France	Terminal Appointment System
4	Manila International Container Terminal	Philippine	Vehicle booking system (VBS)
5	Hong Kong International Terminals	China	Tractor Appointment System
6	PSA Antwerp Terminals	Belgium	Truck Appointment Management System
7	Port Metro Vancouver	Canada	Smart Fleet Trucking

Table 1 List of Some Container Port with TAS

Even though terminal containers call the system differently, yet those systems have similar principle features. The principle features that exist in TAS can be summarized as follows (Terminal, 2005):

1. Setting for gate quota
2. Booking time slot
3. Registration for container and truck
4. Gate validation
5. Administration

TAS has a feature for setting the quota of gate transaction that limits the number of containers to be booked for receiving or delivery in every period of gate service. The period of service could be divided by the hour, day shift or by day depend on the needs of the container terminal. The terminal also could modify the quota setting when required to improve the equipment optimization.

Subsequently, based on the gate quota set by the terminal, the trucks make an appointment through the Booking Time Slot feature by selecting the available gate service time according to the plan of receiving and delivery. The trucker should choose the other time slot if the quota in the designated time is fully booked. The Booking Time Slot also provides functions for amending and canceling the booking.

Furthermore, the trucker has to register the container number and the truck before arriving at the terminal. The registration is important for validation process when the truck arrived at the terminal. The validation process is performed before gate transaction by checking the physical data against the terminal data. Validation aims for security purposes and prevents the truck gate in without an appointment. For a truck that pass validation process could proceed for gate transaction. Meanwhile, for the truck with validation problem should go to the parking area for further administration settlement.

The last feature is administration. Administration feature provides a function for security, financial and reporting. The identity of the container owner, the truck company, and the truck drivers should be validated and recorded properly, to avoid any legal issue in the transaction. Administration feature also covers function for finance settlement between terminal and container owner, such as terminal handling charge, storage, and penalty.

Furthermore, the reporting function consists of detail information of the transaction, tracing and tracking the container movement. Based on the report, the terminal could perform controlling, monitoring and evaluation of TAS for further adjustment of gate quota. The report is also required to evaluate the terminal service performance against the service agreement made with truck companies.

Apart from the principle features, each terminal has their unique characteristics which applicable only in their business process and terminal environment. Take an example in the ports of Los Angeles and Long Beach that offers incentives to the truckers to use off-peak hours. The ports also charge a Traffic Mitigation Fee (TMF) for transactions made during peak hours. The program was successful in redistributing the arrival times of trucks to port terminals throughout the day. Nevertheless, the similar program were not considered to be a success when it was implemented in Port of New York/New Jersey (Merk and Notteboom, 2015, p. 12).

Another unique characteristic of TAS is related to the regulation of penalty that has to be paid by the terminal to the trucker. Port Botany, Australia regulate that terminal should pay a penalty if the truck total turnaround time greater than 50 minutes (single transaction) and AUS\$25 per additional 15 minutes. While Port Metro Vancouver,

Canada regulates penalty to be paid by the terminal operators to the truck carrier for total turn times exceeding 2 hours is CDN\$30 (Davies, 2013, p. 11).

Most of the unique characteristic in TAS implementation is related to policy and regulation. The reason is that every port is unique hence the regulation of TAS embraces the uniqueness of the port. The regulation also should fit with the requirement of terminal stakeholders. Terminal operator, freight forwarders, the truck companies and local government should formulate TAS regulation based on principles of collaboration, respect, engagement, fairness, transparency, accountability, and long-term sustainability (Vancouver, 2013).

The implementation of TAS involves different parties from various companies and also involves some procedures and regulations. Considering its complexity, the needs for reliable information and communications technology (ICT) system is inevitable. The ICT system makes the transaction process simple, user-friendly, real time, and transparent. Thus, the parties involved could communicate smoothly, and the process of controlling and monitoring could be performed efficiently and effectively. For a success TAS implementation, at least two type of ICT system are required, Terminal Operation Systems (TOS) and Radio Frequency Identification Device (RFID) system.

TOS is a main system of the container terminal operation. It controls the movement of container and equipment in gate operation, yard operation, and quay operation. The system also enables internal terminal operation communicate with other systems. In relation with TAS, TOS act as an internal server while TAS acts as an external server. Both systems communicate through Electronic Data Interchange (EDI). TOS transmits operational data and also receive booking information from TAS.

RFID wirelessly transmits object identity and location by radio waves. TAS uses the technology in the process of Gate Validation. With RFID technology, the trucks could be validated without stopping. At the time a truck passing RFID reader, the information will be transfer to TAS system and instantly validated whether the truck is eligible to gate in or not. An eligible truck could proceed to gate in while ineligible truck will be ordered to the parking lot to fix the problem.

The implementation of TAS is indeed challenging and costly for a container terminal. Nevertheless, it has been proved by many container terminals could optimize terminal equipment and improve the quality of service. Referring to from Philip Davies, (2013) about cost/benefits analysis of Port Botany Australia in 2012, the implementation of TAS resulted in the following improvements in efficiency in the first 12 months of operation:

- Reduction in TRT of 30%.
- Increase functionality of trucks arrival time from 72% to 95%.
- Significant reduction in congestion during peak periods.
- Greater uniformity in slot availability across the week.

Unquantified benefits included:

- Safety, environmental, and economic benefits of reduced congestion around Port Botany.
- Benefits to importers and exporters of increased consistency of truck deliveries, and almost complete elimination of demurrage payments.
- Benefits from delay of infrastructure investments.

CHAPTER 3. PROBLEM IDENTIFICATION

3.1. Introduction

All operation strategy in every part of container operation should be managed to achieve an integrated performance for the whole system. Focusing the strategy only in one part of the system may lead to imbalance workload among the operational components . The nature of a terminal in prioritizing quay operation often creates imbalance workload in yard or gate operation. Therefore, optimization process should be performed in a whole system perspective to avoid sub-optimization condition in a particular area (Böse, 2011, p. 91).

Sub-optimization occurs when one area is optimized without considering the impact on the whole system. Consequently, it creates a productivity gap among the operation area. Some areas with high optimization produce more and faster service while un-optimized areas provide less and slower service. The un-optimized areas will turn into critical points or bottlenecks whereby their capacity and performance is a binding constraint on the performance of another site. Eventually, it impacts the aggregate efficiency of the whole system.

Figure 4 illustrates the effect of sub-optimization in a system. Area 1 could reach 100% optimization, by utilizing the whole capacity. When the flow reaches Area 2, the optimization drops to 30%. Subsequently, 70% of the stream is blocked and build queue in Area 1. Only 30% released from Area 2 as input for Area 3. Eventually, Area 3 only produces 30% of output and leave 70% unused.

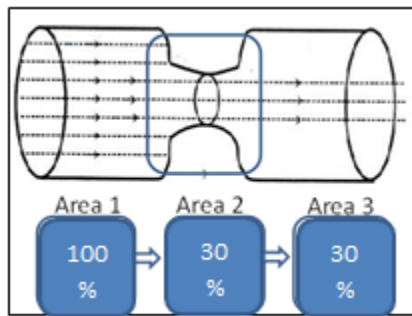


Figure 4 Bottleneck Illustration

The above situation happens in a container terminal with sub-optimization condition. The terminal operation may not be able to produce maximum output due to the existence of a bottleneck component. As container terminal comprises of three groups of operation, the bottleneck may be located at quay operation, at yard operation or gate operation.

The bottleneck of operation mainly derives from the lack of capacity and mismanagement. Lack of capacity indicates that the infrastructure is no longer sufficient to support an effective and efficient operation. There is not enough room for the operation to increase the volume and quality of services, unless by adding the new facility.

Apart from lack of capacity, mismanagement also leads to bottleneck. Mismanagement corresponds to ineffective operating method of the equipment. Hence the equipment unable to reach its maximum performance is expected. The existence of the waste product, idle capacity, idle equipment in the middle of high workload environment are some indication that mismanagement is happening in the organization.

Identification of the bottleneck allows terminal managers to take the right solution and the right measured action to improve the operation performance. In contrary, fail in identification of the bottleneck may lead to the wrong decision and eventually not solve the real problem. In above sample, the bottleneck is assumed located in area 2, a terminal manager should focus in improving the capacity of area 2 to improve the capacity of the whole system. Improving area 2 will automatically improve the capacity of area 3. Nevertheless, if a terminal manager focus in improving the capacity of area 3, then the capacity will never improve. No matter the size of area 3, it will not increase the capacity of the system as the whole system capacity is limited by area 2 as the bottleneck.

Identification a bottleneck in a container terminal operation is more complex than above illustration. Even though terminal operations can be simplified by grouping into three group of operation (quay, yard and gate operation), nevertheless there are some factors inside each group to be analyzed. The bottleneck factor may be sourced from facility, equipment, human resources, system, technology, management. A thorough analysis is required to identify the source of the problem.

3.2. Problem Identification by BCG Matrix Model

There are several methods for evaluation and analysis the bottleneck, the most cited of which is the Business-Consulting Group (BCG) matrix, also called the growth-share matrix. The BCG methodology consolidates the measurement of actual industry market share for each of the firm's Strategic Business Units (SBUs) with related growth rates by classifying four distinct market positions.

The BCG matrix also could be used to evaluate the optimization of container terminal operation. In a container terminal operation context, growth is translated into equipment productivity, and share is translated as the infrastructure capacity. Furthermore, the SBU

could be conceived as operational units, such as quay operation, yard operation, and gate operation.

Through the BCG matrix, operation units will be mapped to identify the bottleneck in the operational of the container terminal. The indicators of bottleneck unit are having the smallest reserved capacity and the lowest reserved productivity among the component. A reserved value indicates the saturation or density of workload in the unit. High reserved values mean that the units still have room to accommodate more workload. In contrary, a unit cannot afford additional workload if the unit has low reserved values.

Furthermore, the BCG matrix categorizes the operational unit into four ranges namely Cash Cow, Dog, Question mark and Star. The Cash Cow is where the operational unit has high reserved capacity with low reserved productivity. Star is a unit with a high reserve capacity in a high reserved productivity. A question mark is an operational unit with a high reserved productivity, but having a low reserved capacity. Moreover, Poor Dog is the unit with low reserved capacity with low reserved productivity. The Poor Dog represents saturated component in BCG matrix. Hence, it becomes a bottleneck for the whole.

The first step in building BCG matrix is choosing the unit of measurement. In this case, the units are quay operation, yard operation, and gate operation. Each unit will be evaluated from two areas of analysis, infrastructure capacity and equipment productivity. The second step is measuring the reserved capacity of infrastructure and reserved productivity of the equipment. The reserved value derives from the gap value between the maximum value and operational value. The maximum value is the highest capacity and the maximum productivity that possible to be provided by the operational unit. The operational value derives from the average capacity and productivity performance during operation:

Reserved Capacity = 100% – Occupancy Ratio

Reserved Productivity =
$$\frac{\text{Maximum Productivity} - \text{Operational Productivity}}{\text{Maximum Productivity}}$$

The third step is categorizing the reserved value into Low, Medium, High and Very High. Referring to OECD (2014), industry intelligence shows that the optimum percentage for a terminal to work at maximum efficiency is in the range 65% to 75%. Hence, the gap between 25%-35% is categorized as High.

Table 2 displays the categories of reserved value for the capacity and productivity. The categories are based on researcher assumption that indicates the availability of a room for further improvement in providing capacity and productivity. Low category means that there is hardly room available for improvement. Medium Category is an indicator of possibility to improve with medium effort. High and very high represent that capacity and productivity have a big portion unutilized.

Ratio	Category of Reserved Value
0.0% - 24%	Low
25% - 35%	Medium
36% - 50%	High
50% - 100	Very High

Table 2 Category of Reserved Value

The last step is placing the operational units into the matrix according to ratio category. The matrix is shaped in one large square and is divided into four equal quadrants. Along the bottom of the box, the reserved productivity is written, and the reserved capacity is

written on the left side. On the bottom left are low reserved capacity and low reserved productivity. On the right-hand side, high reserved productivity is at the top, and high reserve capacity is at the bottom.

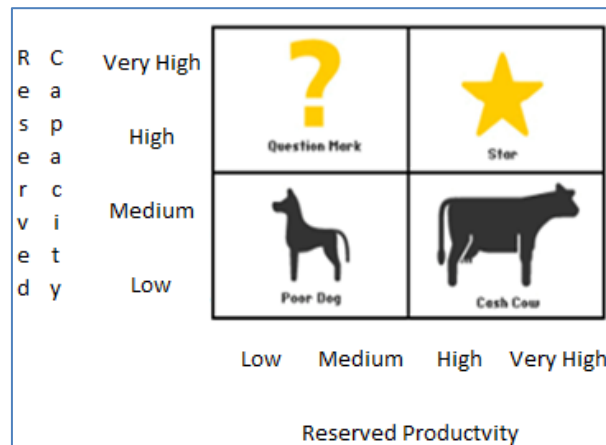


Figure 5 BCG Matrix Model

3.3. Case Study: Jakarta International Container Terminal (JICT)

To apply the analytical methodology, a case study of Jakarta International Container Terminal (JICT) will be presented. JICT is located in Tanjung Priok Port, Jakarta, Indonesia. Over two-thirds of Indonesia’s International trade is shipped through the Tanjung Priok Port. In 2013, container traffic in Tanjung Priok was recorded 6.2 Million TEUs, which equal to 57% of total national container throughput 10,790,450 TEUs (Bank, 2014).

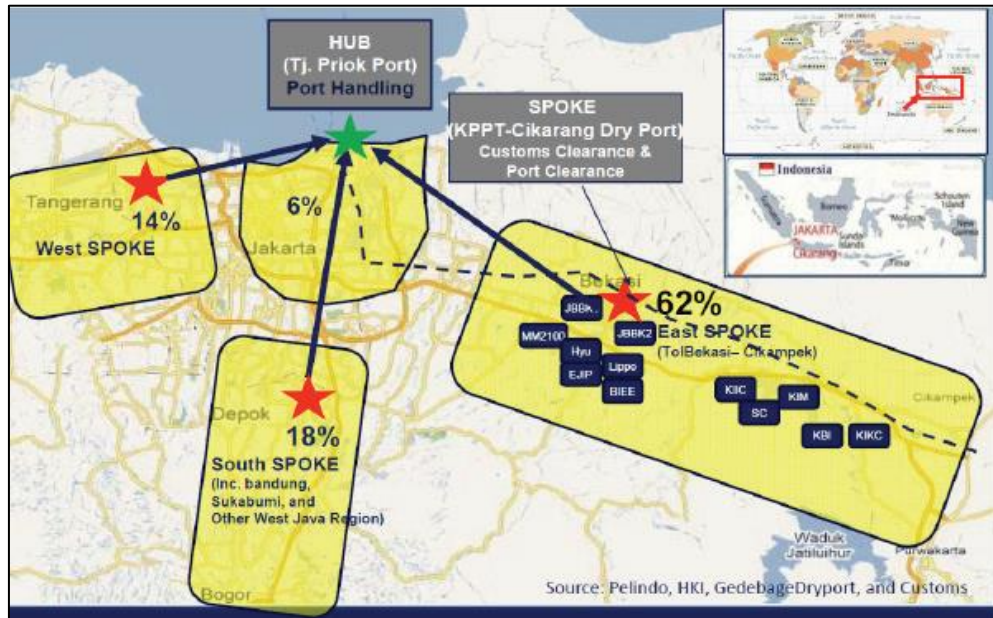


Figure 6 Industrial Hinterland of Tanjung Priok Port

Figure 6 shows that container traffic of Tanjung Priok port derived from the city and industrial area around the port. As illustrated in figure 6, the majority of container traffic is generated by industrial activities around the port. The biggest traffic volume comes from the industrial area on the east side which account for 62% while the other industrial zones in south and west contribute 18% and 14% respectively. Jakarta as the city generates 6% of the traffic. Categorized as one of the densest city in the world, Jakarta gives a substantial contribution to the growth of Tanjung Priok Port.

Together with container traffic contribution from the other industrial area, Tanjung Priok Port is visited by more than 16,000 TEUs containers per day. The container traffic is distributed to three container terminals inside the port i.e. Terminals 009, KOJA Terminal, and JICT. Terminals 009 comprises of several small terminal operators inside, in total handled 2.9 million while the other single operator terminals, KOJA and JICT handled 0.83 million TEUs and 2.4 million TEUs, respectively.

JICT is the biggest single operator terminal in Tanjung Priok Port. It covers 39% of total container traffic of the port. JICT has two terminals, Terminal 1 Terminal (JICT-T1), and Terminal 2 (JICT-T2). Terminal 1 is the main terminal, with superior facility and equipment, while Terminal 2 is hardly operated due to the limitation of water draft and equipment. Therefore, this paper will associate all discussion about JICT with operation in JICT-T1 only.

JICT-T1 has 1640 meters length of the berth, with draft 11-14 meters. The quay deck is L-shaped, comprises of The West berth 900 meters length and north berth 740 meters length. Each berth is equipped with eight cranes with Berth Occupancy Ratio (BOR) was 52%. JCT-T1 container yard covers 45.54 Ha, with total ground slot 1720 unit and average Yard Occupancy Ratio (YOR) was 85%. JICT-T1 also equipped with five entrance lanes, five exit lanes and parking lot with capacity for 400 trucks with average parking utilization (POR) 45%.

1. QC (Quay Crane)

As per record in 2013, JICT-T1 had 16 units of QCs. Nevertheless, maximum deployment of QC in a day was recorded 14 and 15 units (Figure 7). The average number of QC deployment in hourly basis was relatively stable extends from 8 units to 10.5 units with average 9.1 units/hour (Figure 8).

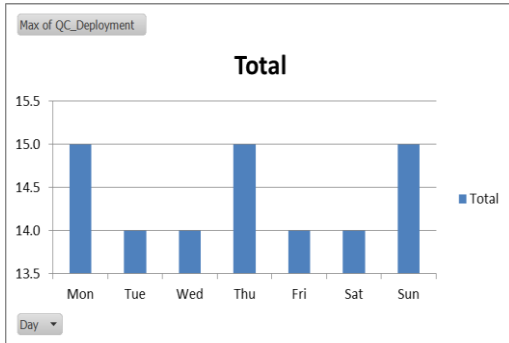


Figure 1 Max. Deployment: unit/day

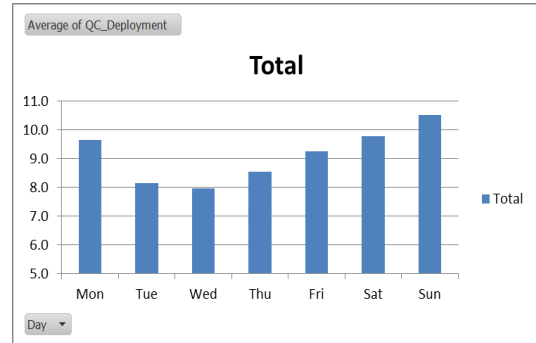


Figure 2 Avg. Deployment: unit/hour

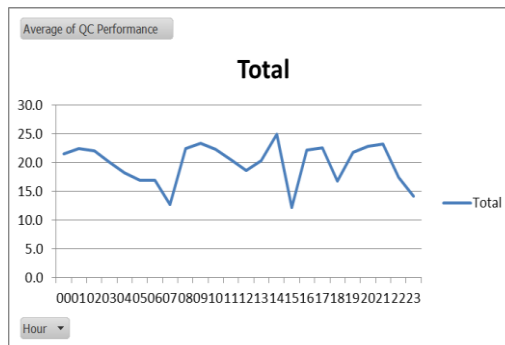


Figure 3 Avg. Performance: Box/hour

While QC deployment had a steady pattern, QC productivity in hourly basis had a bigger fluctuation extend from 12 to 25 moves per hour with average 19.8 moves per hour. QCs Productivity fluctuated in every hour; the lowest level was reached at shift change at 07:00,15:00 and 23:00. The productivity increased up to the middle of the shift and turned declining until the next shift change (Figure 9).

2. Rubber Tired Gantry Crane (RTGC)

Total number of RTGC of JICT-T1 in 2013 was 63 units. Nevertheless, according to the record, maximum daily deployment was only 45 units while the average daily average was 36 units (Figure 10, Figure 11). The other units were not operated due to some

mechanical problem. RTGC performance in hourly basis fluctuated at range 8 to 16 moves/ hour with average 14.2 moves per hour (Figure 12). Similar with QC performance, RTGC performance declined in shift change time and increased up to mid of shift.

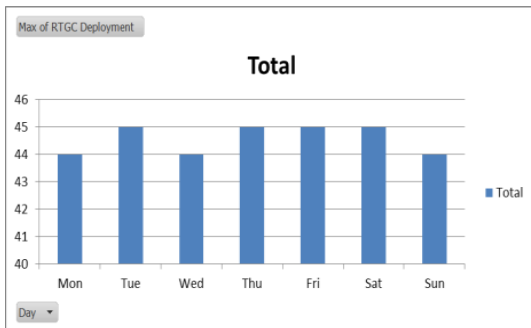


Figure 10 Max. Deployment: unit/day

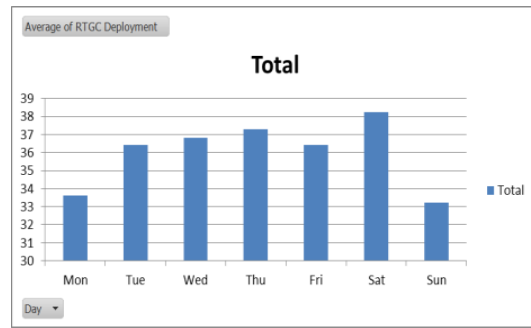


Figure 11 Avg. Deployment: unit/hour

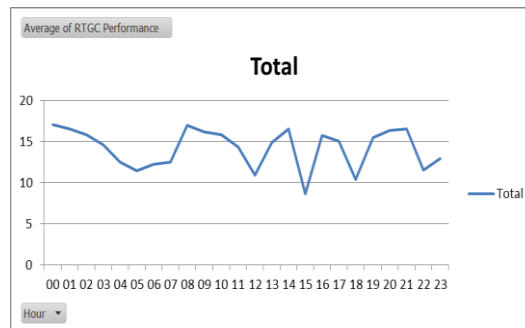


Figure 12 Avg. Performance: Box/hour

3. Front Loader FL / Reach Stacker RS

Apart from RTGC, JICT deployed Front Loader to support yard operation. FL deployment mainly was allocated to serve empty container and special containers, such as over dimension, flat rack, and un-containerized cargo. From total 6 unit reach stackers, maximum daily deployment was 5 (Figure 13) and average deployment was 2.4 units per day (Figure 14).

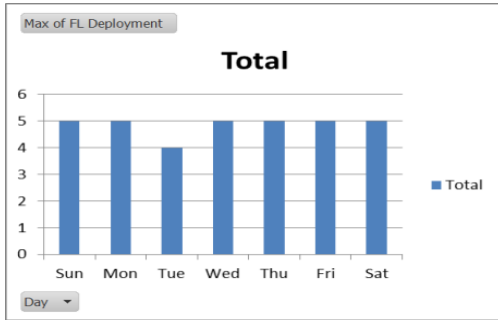


Figure 13 Max. Deployment: unit/day

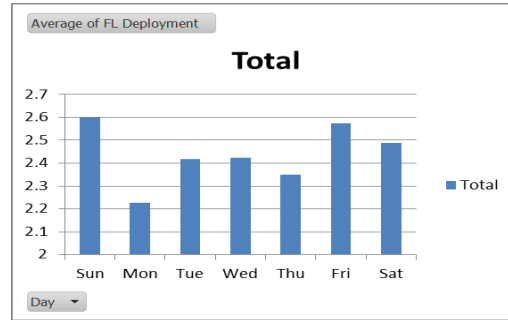


Figure 44 Avg. Deployment: unit/hour

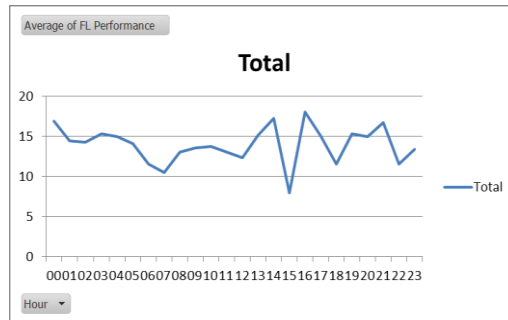


Figure 15 Avg. Performance: Box/hour

Reach stacker had similar function and same performance as RTGC, with 13.9 moves/hour. Using the same performance benchmark as RTGC (15 moves/hour), the productivity of RS was 93% similar operation pattern as RTGC (Figure15).

4. Gate

JICT-T1 had five entrances for the gate in and five exits. The gates were equipped with an auto gate system that could handle 8000 transactions/day or in average 333 transactions/hour (Figure 16). Nevertheless the average transaction per day was the only 4383/day, with the lowest number of the transaction was 2504/day and the highest was 5620 transaction/day (Figure 17). In hourly basis, gate transaction fluctuated in the same pattern as QC and RTGC, with the average transaction was 182.6 transactions per hour (Figure 18).

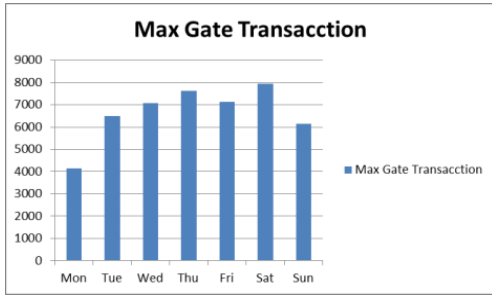


Figure 16 Max. Deployment: unit/day

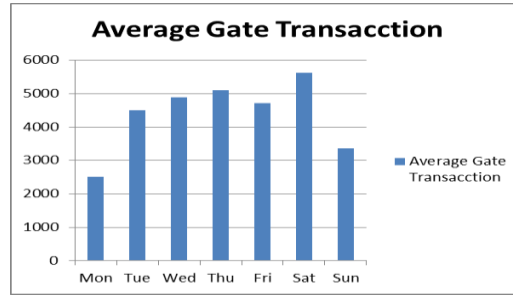


Figure 17 Avg. Deployment: unit/hour

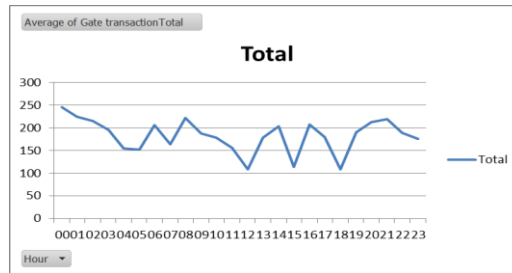


Figure 18 Avg. Performance: Box/hour

Evaluation of BCG Matrix

From above facilities and equipment information, a BCG matrix could be developed to identify the bottleneck of the JICT operation.

Infrastructure Capacity			
Unit	Utilization%	Reserved %	Category
Quay	52%	48%	High
Yard	85%	15%	LOW
Gate	45%	55%	HIGH

Table 3 Infrastructure Capacity Mapping

Equipment Productivity				
Unit	Max BCH	Ave.BCH	Reserved %	Unit
Quay	375	180	52%	High
Yard	735	674	8%	LOW
Gate	333	183	45%	HIGH

Table 4 Equipment Productivity Mapping

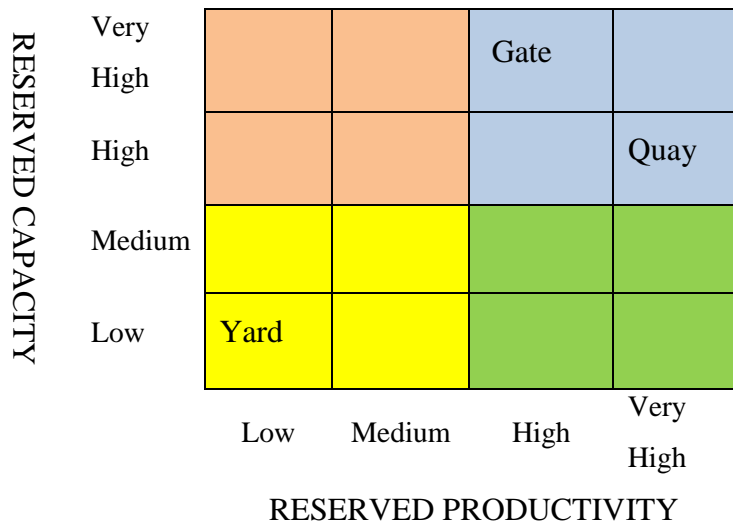


Figure 19 BCG Matrix Mapping

The BCG matrix shows that yard operation has the low reserve capacity. The reserved capacity indicates that yard operation environment has been saturated. Yard operation has the small possibility to increase the capacity as current yard density has been so high. The limitation capacity in the yard also becomes a limit for quay and yard operation. Even though the reserved capacity of quay and gate are still high, but their free capacity could not be utilized.

Apart from the limitation of reserved capacity, yard operation also has low reserved productivity. It means yard operation productivity is reaching to the maximum limit. Hence the opportunity to improve the performance of yard operation is minuscule. Similar with the limitation of capacity, limitation of performance also limit quay and gate operation. Both quay and gate operation should maintain their productivity to fit with yard operation productivity.

The above indications conclude that yard operation is the bottleneck of the system. Nevertheless, the BCG matrix model only provides an initial indication of a problem. It does not give detailed information on the reasons behind the problem. Therefore, further analysis of yard operation as the bottleneck of the operation is required to get better understanding of the root of the problem. Further analysis will be discussed in the next chapter.

CHAPTER 4. PROBLEM ANALYSIS

4.1. Yard Operation Productivity

In line with the objective of this dissertation to optimize the existing container terminal equipment, this chapter will analyze the problem related to the equipment. Even though yard operation has been indicated as the bottleneck by having capacity limitation and productivity limitation, nevertheless, this chapter will investigate the yard productivity limitation that related to equipment utilization.

Yard productivity is highly relevant to the number of equipment and performance of the equipment. The productivity will increase along with the rise in the number of equipment and or the improvement of equipment performance. Yard Productivity is measured in Box Container per Hour (BCH). BCH is derived from some container movement (C_m) that could be handled by equipment deployed (E_d) in one hour.

To be able to understand the relationship between C_m and E_d , a simple linear regression is run. Simple linear regression analysis finds a straight-line equation between the values of two numeric-random variables only. The one variable is called the independent or predictor variable, x , and the other is termed the dependent or response variable, y . Independent variable (x) The independent variable is represented by the symbol x . It is the variable influencing the outcome of the other variable (Wegner, 2012. p. 408).

In this case, y variable is represented by the average of container movement (C_m) while x is presented by the mean number of yard equipment deployment (E_d). Furthermore, the simple linear regression is visualized through a scatter graph as presented in Figure 20.

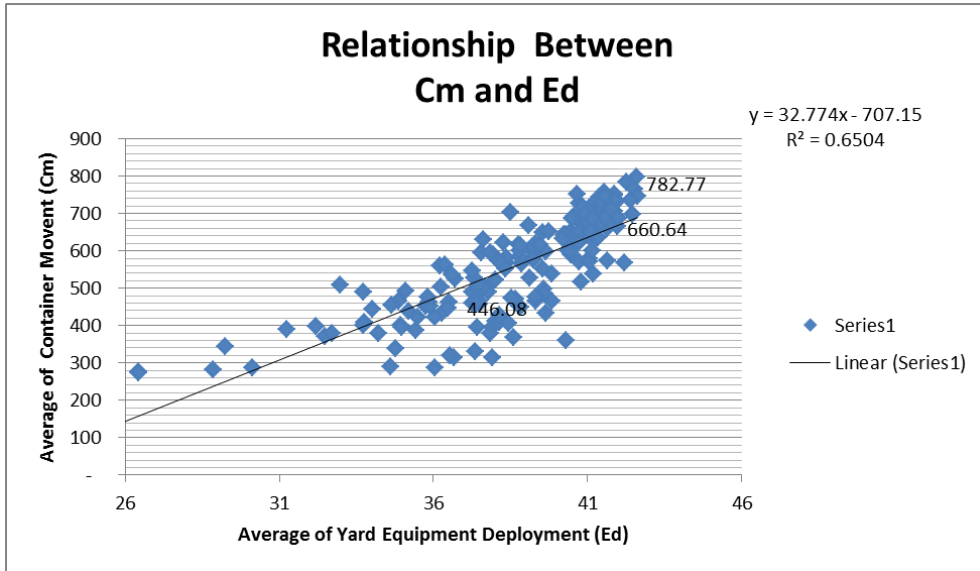


Figure 20 Scatter Graph of Relationship Between Cm and Ed

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.81
R Square	0.65
Adjusted R Square	0.65
Standard Error	77.74
Observations	175.00

ANOVA					
	df	SS	MS	F	Significance F
Regression	1.00	1,945,345.00	1,945,345.00	321.89	0.00
Residual	173.00	1,045,516.75	6,043.45		
Total	174.00	2,990,861.76			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	(707.15)	70.62	(10.01)	0.00	(846.54)	(567.77)
Average of Total Yard Equipment deployed	32.77	1.83	17.94	0.00	29.17	36.38

Table 5 Summary Output of Regression

The scatter graph display relationship between Cm and Ed. The regression value, $y = 32.774x - 707.15$, shows a positive correlation between two factors. When Cm increases,

Ed will increase. The value of R^2 is = 0.6504 indicates that 65% of Cm could be explained by Ed. Furthermore, Table 5 displays that the regression has estimated the coefficient of t-stats 7.25 which correspondence to p-values 0.00. It reflects a high confidentiality level of the regression that is greater than 95%.

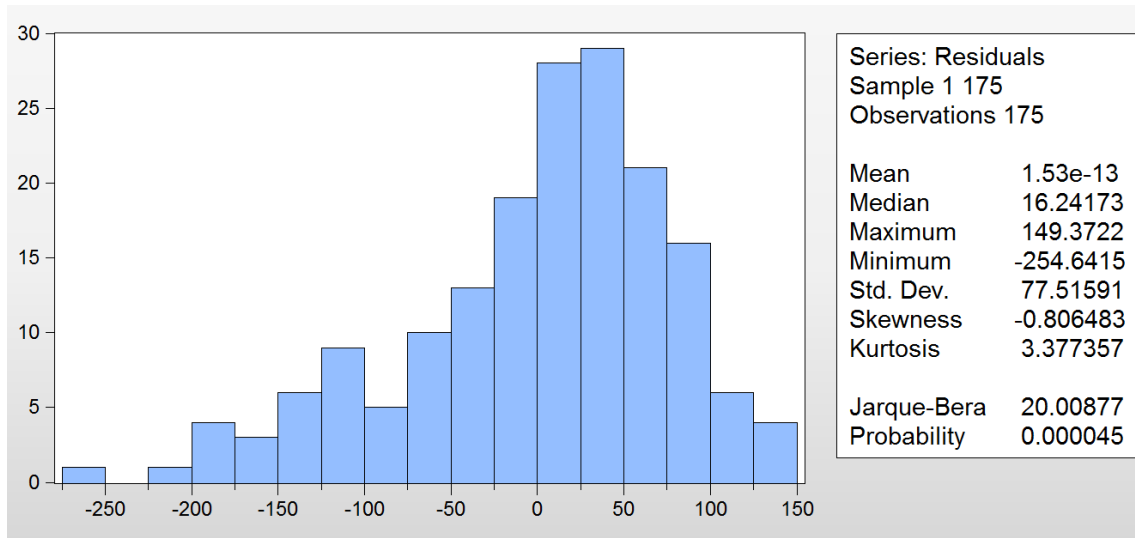


Figure 21 Histogram-Normality Test

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	1.846643	Prob. F(2,171)	0.1609
Obs*R-squared	3.699770	Prob. Chi-Square(2)	0.1573

Test Equation:
 Dependent Variable: RESID
 Method: Least Squares
 Date: 08/27/15 Time: 16:47
 Sample: 1 175
 Included observations: 175
 Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	32.35931	75.40932	0.429116	0.6684
ED	-0.840227	1.951546	-0.430544	0.6673
RESID(-1)	0.022409	0.078170	0.286678	0.7747
RESID(-2)	-0.148474	0.078724	-1.885996	0.0610

R-squared	0.021142	Mean dependent var	1.53E-13
Adjusted R-squared	0.003969	S.D. dependent var	77.51591
S.E. of regression	77.36195	Akaike info criterion	11.55746
Sum squared resid	1023413.	Schwarz criterion	11.62980
Log likelihood	-1007.278	Hannan-Quinn criter.	11.58680
F-statistic	1.231095	Durbin-Watson stat	1.995191
Prob(F-statistic)	0.300032		

Table 6 Serial Correlation Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.618843	Prob. F(1,173)	0.2050
Obs*R-squared	1.622376	Prob. Chi-Square(1)	0.2028
Scaled explained SS	1.884656	Prob. Chi-Square(1)	0.1698

Test Equation:
 Dependent Variable: RESID^2
 Method: Least Squares
 Date: 08/27/15 Time: 16:47
 Sample: 1 175
 Included observations: 175

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16595.96	8377.139	1.981101	0.0492
ED	-275.7027	216.6900	-1.272337	0.2050

R-squared	0.009271	Mean dependent var	5974.381
Adjusted R-squared	0.003544	S.D. dependent var	9238.141
S.E. of regression	9221.757	Akaike info criterion	21.10788
Sum squared resid	1.47E+10	Schwarz criterion	21.14405
Log likelihood	-1844.940	Hannan-Quinn criter.	21.12255
F-statistic	1.618843	Durbin-Watson stat	1.943513
Prob(F-statistic)	0.204961		

Table 7 Heteroskedasticity Test

Further test by using EViews software, the diagnostic shows that the data in this analysis is desirable statistically. The Residual Diagnostic results in Figure 21 display the histogram of Normality test. The value of normality tests shows that the residuals are normally distributed, represented by a bell-shaped and the Bera-Jarque statistic value is bigger than 0.05. It means that the null hypothesis of a normal distribution is accepted. The normality test gives a researcher a confidence that the data used is normally distributed. Further test in table 6, serial correlation test has indicated that the residual data has no serial correlation as represented by the value of Prob.Chi-Square (2) at 0.15 which means above 0.05. Finally, the Heteroskedasticity in table 7 displays the value of Prob.Chi-Square (1) is 0.1 which means P-Value is bigger than 0.05 and concludes that residual is homoscedastic.

The Cm has a broad range of value expanding from 29 to 782. The Cm values reflect average workload per hour of yard operation that consists of some container movement. Ed fluctuates in relatively smaller range, with minimum 3 and maximum 42. The Ed pattern shows the average number of yard equipment deployed for every hour.

Figure 20 displays Cm values divided by a trend line into two groups. The Cm values located below the trend line indicate a situation when some container movement is less than the average number of deployed equipment. In contrary, when Cm values are located above the trend line, it indicates that container movement volume is bigger than the mean number of deployed equipment. The values above the trend line may indicate that terminal is experiencing over workload situation.

Obviously, over workload situation could be seen at the end of the trend line. The Value of Ed stops at 42 while the value of Cm increases exceeding 660 up to 787, above the trend line. Similarly, the same indicator of an over workload situation also exist in the middle of the trend line. It means that an over workload situation does not only occur

because of no more equipment available but also happen when the terminal does not deploy available yard equipment properly to handle the volume of container movement.

Given yard operation serves quay and gate operation, limitation of equipment in yard operation will affect to quay and gate operation. Yard operation volume will dictate the total volume of quay and gate operation. Even though quay and gate operation still has reserved capacity to generate more movement, yet the capacity cannot be utilized due to a limitation in the yard. The situation is illustrated in Figure 22.

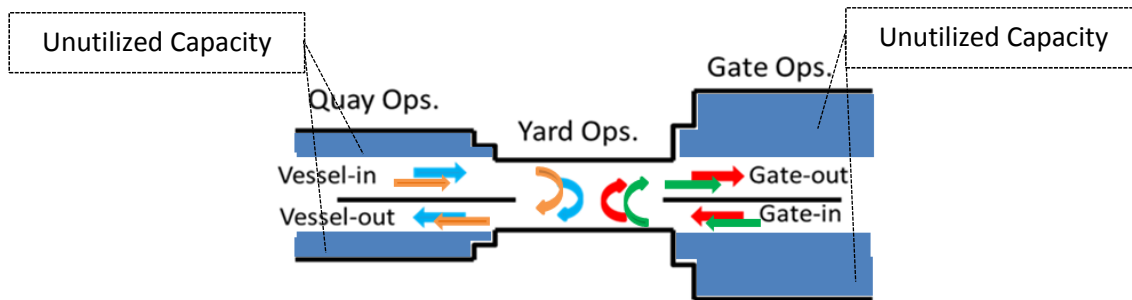


Figure 22 Unutilized Area at Quay and Gate

Both the BCG matrix and the simple linear regression analysis confirm that there is an imbalance condition in the operations. Quay and gate operation as the feeder have a bigger reserved capacity than yard operation. Further analysis will investigate yard operation in detail to understand why yard operation becomes the critical point in container terminal operation.

4.2. Yard Operation Workload

Previous chapter revealed that yard operation is the critical point in container operation. Even though yard operation has a bigger capacity and more equipment than quay and gate operation, yet yard operation is still considered as the weakest point in the system. It is because yard operation has more workload than quay and gate operation.

The sources of yard operation workload are not only from quay operation and gate operation but also from internal yard operation. Workload from quay operation derives from trucks serving the vessel for discharge and loading. Secondly, the workload from gate operation, it derives from external trucks performing receiving and delivering a container. The last is workload from internal yard operation, derives from the needs of yard operation to relocate containers for better yard utilization.

Yard operation considers workload sourced from quay as the priority. The reason is that the quay operation serves the vessel that is the primary customer of the container terminal. Terminal serves the vessels according to agreement with shipping lines, which so-called 'Berthing Contract.' The contract mentions a tight berthing schedule with exact berthing time, departure time and service standard that has to be fulfilled by the terminal. For these reasons, terminal deploys more equipment to serve quay operation and to protect the vessel berthing schedule on time. A fail in keeping a vessel berthing schedule not only costs claim from shipping line but also jeopardizes the whole berthing schedules of the vessels.

The second source of yard workload is gate operation. As mentioned in the previous chapter, the terminal considers gate operation as a second priority. Gate operation serves external trucks for receiving and delivery containers. Traditionally, the terminal does not have a service contract with the external truck. Hence, trucks visit the terminal at any time without any fixed schedule. It is normal for the truck to have a reasonable waiting time before getting terminal service. Nevertheless, a long waiting time may triggers complaint from the trucker and also produces longer truck queue, which has been explained in the previous chapter.

The last source of yard workload is internal yard operation. The terminal performs internal yard movement known as marshaling. Marshaling relocates containers for better

yard allocation as preparation for loading operation and delivery operation. Marshaling is performed to reduce shuffling movement during loading and delivery. Marshaling is also performed when some part of the yard is required for civil work. Marshaling activity is fully under the control terminal, thus it is the terminal who decide the time and the number of containers to be marshaled.

The quay, gate, and internal yard have a different level contribution to yard workload. The workload contribution depends on the type of container terminal. A transshipment container terminal will have more quay workload than gate workload as transshipment container moves around the quayside, from one ship to the others without passing the gate. In export-import container terminal, the composition between quay and gate operation are relatively balanced, as every container that enter terminal will be loaded on board and vice versa. In other terminal, gate operation may be more than quay operation as some containers should perform several gate transactions for customs inspection.

Meanwhile, marshaling activity, as the only workload sourced from internal yard operation, is the least component in every terminal. Marshaling is considered as an unproductive move by the terminal. Hence terminal will not perform marshaling unless it is needed to avoid more shuffling during loading or delivery. Böse (2011, p. 256) explained the goal of the marshaling problem is to reshuffle containers so that no further relocations, i.e. unproductive moves are required when the loading/unloading phase is performed.

In case of JICT, the composition of yard operation workload is displayed in Figure 23. As JICT is an export and import container terminal, the workload sourced from quay and gate operations are relatively balanced, 45% and 47% respectively. Gate operation is slightly bigger than quay workload due to some customs inspection required containers

to perform several gate transactions. Meanwhile, the proportion of internal yard movement is only 8% of total yard movement.

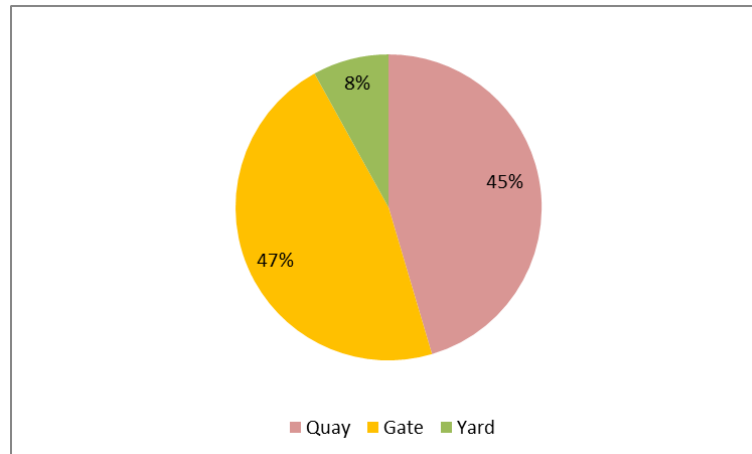


Figure 23 Yard Workload Composition

Considering the sources and the composition of yard workload, gate operation is the source that needs to be control by JICT. Controlling workload from quay operation is difficult as it bounded by tight vessel schedule and berthing contract. Meanwhile, managing controlling workload from internal yard is relatively small and not significant. In contrast, the workload from gate operation does not have a schedule and covers a big portion of yard workload. Hence, controlling workload derives from gate operation will give an important influence on yard operation. Gate management is the major planning activities dealing with the space usage of a container terminal (Yang, Chen, and Song, 2013, p. 33).

4.2. Yard Operation Optimum level

The first step in managing yard workload is to understand the optimum level of yard operation. By having information of the optimum level of yard operation, the terminal has a benchmark in making a decision relating to yard workload management. The information is useful in the planning process to limit the target workload of quay and

gate operation. In the operational process, the information is required as a benchmark in monitoring process to keep the operational workload at an optimum level.

In case of JICT, yard operation has average productivity 674 BCH. The value 674 is the limit number to accommodate quay operation, yard operation, and shuffling activity. Shuffling activity is an extra movement resulted from serving gate operation and yard operation. A shuffling activity commonly expressed in percentage/ ratio against total movement of quay and gate operation. In JICT case, the ratio of shuffling is 34% of the total movement. Therefore, to set benchmark value for the optimum level of quay and gate operation, the capacity of the yard is reduced 34%.

Yard max productivity	: 674 BCH
Shuffling rate	: 34%
Yard net limit productivity	: Max productivity – (Max productivity X Shuffling Rate)
	: 672 – (672 X 34%)
	: 445 BCH

Linear programming is used to find the optimum productivity of quay and gate operation. Linear programming is a function that uses an objective to find the optimum solution from amongst the several feasible solution to a linear programming problem (Shenoy, 2008, p. 44). Data related to the quay, yard and gate operation from JICT is collected to define some constraints on the program. The linear programming run as follows:

1. Set the objective: Maximize Total Movement (Quay + Gate Movement)
2. Set the deployed equipment as the variable to change
3. Set the constraints
 - a. Yard constraint : Maximum 445 movement
 - b. Quay constraint : Maximum QC deployment = 15 unit
: Maximum QC productivity = 25 BCH

- c. Gate constraint : Maximum gate lane = 10
: Maximum gate productivity = 55 BCH
4. Run the solver linear programming:

Operation	Quay	Gate
Maximum Performance/hour	25	55
Deployed Equipment	7	5
Movement/ hour	187	258
Total Movement	445	

Table 8 Solver Linear Programming Result

The solver found a solution with all constraints and optimality conditions were satisfied. The result shows that the total optimum movement of quay and gate is 445 movements per hour. It consists of 187 movements of quay operation and 258 movements of gate operation. The solver also advises not to deploy all available equipment, 15 cranes and ten gate lines, to deal with yard limitation. With the performance of Quay Crane 25 BCH, only seven cranes are required. Furthermore, with 55 BCH of gate performance per lane, only five lanes of the gate are required.

However, it is important to note the limitations of the simple linear programming analysis. First, the solver result is only valid when all constraint related to the number of equipment and performance is fulfilled. Secondly, the movement/hour is the best combination of quay and gate transaction number based on mathematical calculation without considering buffer risk that terminal could afford.

In the operational level, the terminal could afford some risks that caused by handling more than optimum movement. For an instant, terminal considers it is still acceptable to handle more movement even though the trucks should wait longer time for getting the terminal service. Another example terminal could afford to have truck queuing in the parking area to gain more movement than optimum level.

The basic notion is, whenever terminal handle more than optimum level there will be some impacts to the quality of service. The impact could be estimated quantitatively but the willingness to accept the impact cannot be measured.

4.3. Managing Yard Workload

As explained in the previous section, workload derives from gate operation is significant to be controlled. Nevertheless, container terminal take a different approach to managing the gate workload. Some container terminals control the gate workload by regulating the external truck arrival while other terminal let the external truck arrive unscheduled.

Terminals that let the truck arrivals unscheduled have a risk of suffering over workload. Due to an absence of controlling in truck arrivals, the yard workload becomes highly fluctuated. The problem arises when a high volume of external truck arrives in the same time with high volume of discharge and loading. The yard become over workload and consequently, the workloads will spillover either to quay operation or to gate operation.

When over workload occurs, the terminal manager takes a decision on the direction of workload spillover based on the priority of the terminal. When the terminal manager prioritizes the gate operation, more yard operation equipment will be used to serve the gate operation. Consequently, the performance of quay operation will be reduced. In contrary, when the decision is to prioritize the quay operation, then more equipment will be deployed to secure the vessel operation.

Prioritizing quay operation is commonly considered as serving shipping lines that are the primary customer of the terminal. The terminal manager prefers to allocate more yard operation to serve the vessel and ‘sacrifice’ the gate operation . However, a lower priority is usually given to the gate side operation than to the vessel side operation

because the control problem of discharging and loading containers is complicated but more important (Kim and Lee, 2015, p. 53-54).

4.4. Measuring the Impact of Over Workload to Gate Operation

In case of JICT, terminal do not have control the truck arrival, hence no control against yard workload. JICT also gives more priority to the quay operation than to gate operation. There is a potential risk for JICT operation, especially for the gate operation. At the time yard allocation is prioritizing the quay operation, trucks coming from gate operation have to stay longer in the terminal and building queues. When the queues accumulation keeps continuing, the queues of trucks may block the access road outside the terminal. Public transportation will be affected and trigger congestion around the port.

A fluid based approximation method is used to describe an over workload situation int the terminal. Fluid based approximation considers queue as a fluid flowing through a pipe system. The fluid is loaded into the system and discharged from the system at particular intervals. When discharge volume less than load volume the system produces backlog that will be added to the system at next interval time.

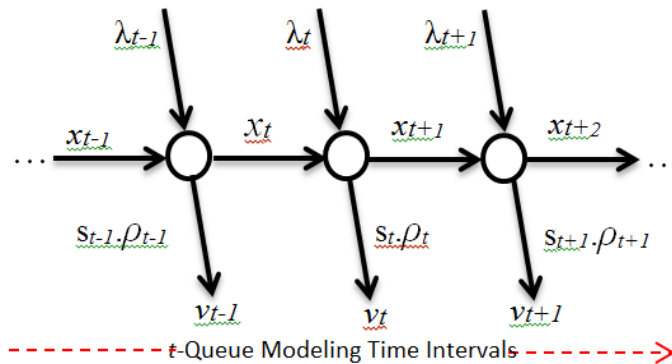


Figure 24 Queue Modeling Time Intervals (Chen, Zhou, and List, 2011, p. 3)

Figure 24 illustrates a network flow representation of the analytical fluid-based approximation scheme. The symbol are explained as follows:

t = time intervals (hour)

λ_t = workload from quay + gate operation t

S_t, ρ_t = service of yard operation t

(S_t = deployed equipment, ρ_t = equipment productivity)

v = The actual discharge rate t

x_t = Backlog (truck-gate operation) t

The model illustrates yard workload situation at (t) hours, (λ_t) flows into the yard, where (x_t) has been existing, resulted from previous hour operation. Furthermore, ($\lambda_t + x_t$) mixed as total workload. Yard operation will serve up to the maximum level of productivity S_t, ρ_t then discharge at (v). When S_t, ρ_t is lower than ($\lambda_t + x_t$), then it will create another backlog (x_{t+1}) for an incoming hour.

The flow of balance and exit are formulated as follow:

Flow balance function:

$$x_{t+1} = x_t + \lambda_t - v_t \quad \forall t$$

Exit flow function:

$$v_t - S_t \cdot \rho_t \leq 0 \quad \forall t$$

Since terminal in nature prioritizes quay operation, this simulation will take the assumption that terminal is ‘sacrificing’ gate operation. Hence, the impact of over workload is assumed only affect to gate operation, where some external trucks are unserved and create backlog workload. The situation of yard operation and its impact on gate operation is illustrated with an assumption as follows:

λ_t =historical data, an average of six months data.

$S_t \cdot \rho_t = (v) = 445$ moves/ hour

$t =$ hour

A calculation using fluid-based approximation scheme, resulting an average of x_t , which represent some un-served external truck waiting for service in every hour. Figure 25 displays the backlogs are always showed up, with Sunday and Monday are the lowest and Friday and Saturday are the highest.

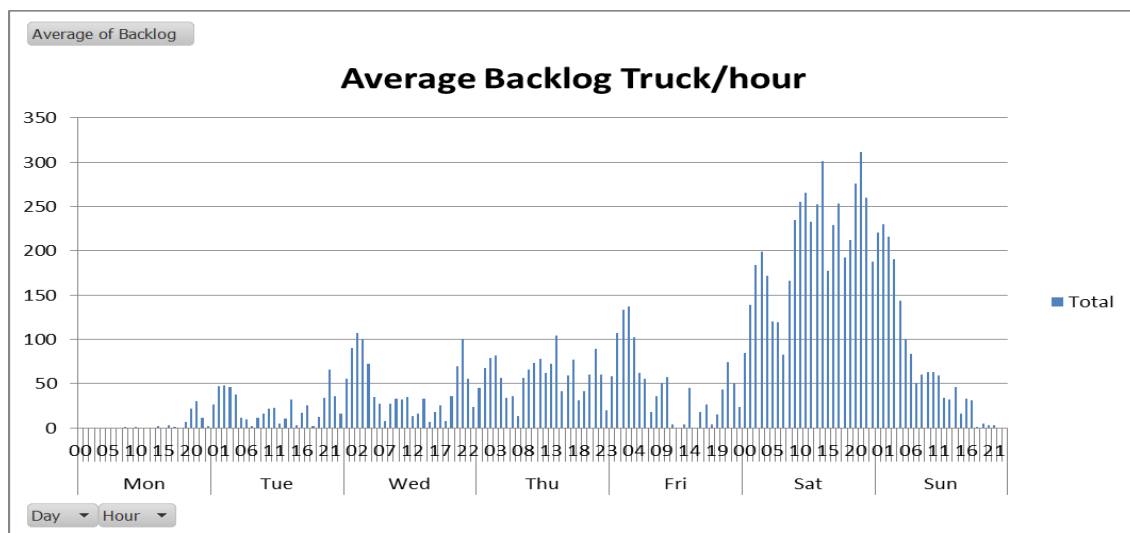


Figure 25 Averages of Backlog Truck/hour

The graph displays some backlog trucks (x_t) that spent more than one hour stay inside the terminal. Assuming terminal serves the truck by First In First Out (FIFO) and the backlogs trucks (x_t) are waiting in the parking area. At $(t+1)$ the backlog trucks (x_t) will be staying with the incoming truck, that belong to $(t+1)$. Hence the total number of trucks remain in the parking area at $(t+1)$ equal to $(x_t) +$ truck $(t+1)$, as illustrated in Figure 26.

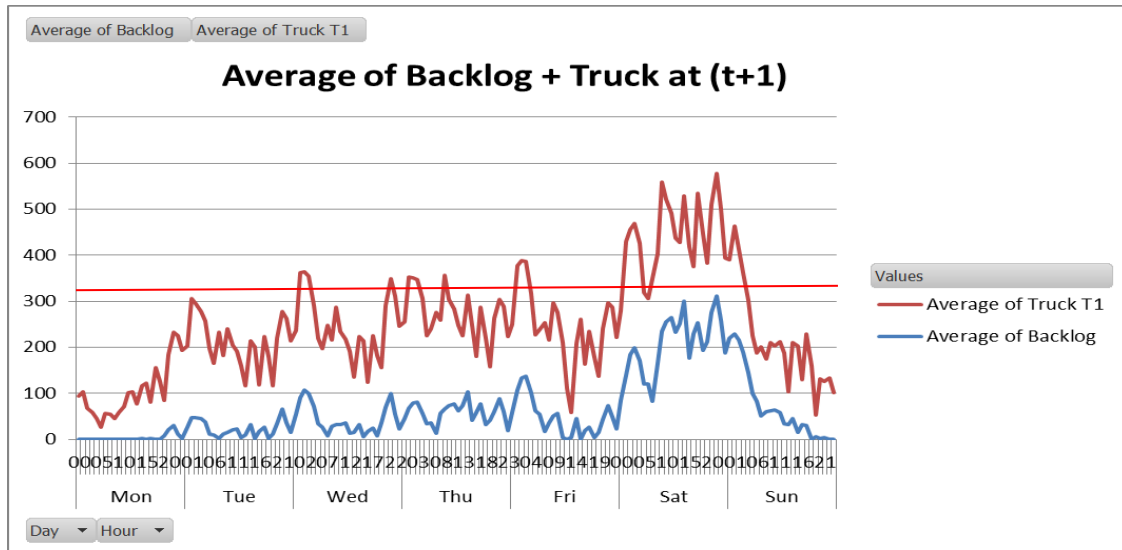


Figure 26 Averages of Backlog + Truck at (t+1)

Taking the peak time, for example, on Saturday 21:00, the average number of backlog (X_t) is 311 units and the average truck at (t+1) is 266 unit. Total truck at (t+1) is 577 unit, park at the parking lot. According to JICT data, the design capacity of parking area could accommodate 400 truck. Nevertheless, considering some broken space during operation, only 85% capacity is effectively used. It means only 340 trucks could park inside the terminal area while the other 177 trucks should park outside, along the access road (public road). The length of truck queue could be estimated as follows:

$$\begin{aligned}
 \text{Number of truck (Tn)} &= 237 \\
 \text{Length/ truck (Tm)} &= 18.5 \text{ m} \\
 \text{Number of queue lane (Ln)} &= 2 \\
 \text{Length of truck queue (Qm)} &= Tn \times Tm / Ln \\
 &= (237 \times 18.5) / 2 \\
 &= 2192 \text{ meters.}
 \end{aligned}$$

A public road is not designed and designated for parking. When the backlog of 237 trucks is parking on the public road, they build more than two kilometers queue and definitely would create traffic congestion. The traffic congestion in the port access road may trigger traffic congestion to neighboring public road network. Eventually, the terminal problem becomes a public concern. Nevertheless, as displayed in Figure 26, the over workload situation, which lead to traffic congestion, does not happen all the time. It happens at some hour in the afternoon on Wednesday, Thursday, Friday, and whole day on Saturday. The rest of time in the week, terminal enjoys relatively small workload.

The result of the fluid base approximation analyzes is similar to the actual traffic condition in the port. The length of the truck queue was identified by previous studies about port of Tanjung Priok. ” There is huge congestion in and around the port, with frequent queues before the gates of several kilometers long (OECD, 2014, p. 239). Another researcher also noticed, the congestion on the weekend, ...and to reduce congestion on weekends, in particular, when traffic was most dense (Hill, 2014, p. 397)..

CHAPTER 5. PROBLEM SOLVING USING TAS

The analysis in the previous chapter shows that the container terminal experiences over workload situation when they do not control truck arrivals. To prevent over workload situation terminal container need to control the truck arrival by implementing TAS. The terminal will be able to monitor the workload of yard operation in optimum level as one of the main workload contributors, the gate operation is controlled.

Controlling gate operation is performed by setting gate quota for a particular window period of gate services. The window period of service could be fixed within an hour, two hours, shift or even a daily base. TAS limits the number of containers performing gate transaction for every window period of service. Gate is functioning as workload regulator for yard operation. When total inflow workload from the quay and internal yard is high, then the inflow from yard should be less, and vice versa. The limit of the gate transaction should be adjusted according to the yard optimum limit and workload input from quay operation and internal yard operation.

Optimum yard = Quay input + Yard input + Gate input

→ Gate input = Optimum yard workload – (Quay input – yard input)

In case of JICT, the optimum yard workload is 445 unit/hour. Considering the quay input derives from the average movement of QC and yard input is the average of marshaling, 8% of the total workload. The quota of gate workload for every hour could be calculated in Table 9:

Hours	Optimum Yard Workload (1)	Marshaling Workload (8% of Optimum Yard Workload) (2)	Quay Workload (3)	Gate Workload quota (4) 4=1-2-3
00	445	35.6	191.6	217.8
01	445	35.6	203.4	206.0
02	445	35.6	197.4	212.0
03	445	35.6	182.6	226.8
04	445	35.6	166.8	242.6
05	445	35.6	144.0	265.4
06	445	35.6	135.4	274.0
07	445	35.6	95.7	313.7
08	445	35.6	192.2	217.2
09	445	35.6	213.7	195.7
10	445	35.6	211.5	197.9
11	445	35.6	198.0	211.4
12	445	35.6	178.9	230.5
13	445	35.6	192.8	216.6
14	445	35.6	223.2	186.2
15	445	35.6	100.0	309.4
16	445	35.6	200.0	209.4
17	445	35.6	210.4	199.0
18	445	35.6	161.0	248.4
19	445	35.6	208.0	201.4
20	445	35.6	212.4	197.0
21	445	35.6	209.4	200.0
22	445	35.6	145.4	264.0
23	445	35.6	114.2	295.2

Table 9 Gate Workload Quota Calculation

Table 9 illustrates the quota of gate transaction per hour in one day. The quota limits number of containers that allowed entering terminal for every hour. The quotas are different for every hour adjusting the number of workloads from quay operation. By controlling the quota of gate transaction, the optimum workload of yard operation could be maintained at 445 movements per hour.

The same methodology applies for gate quota in one week. Since the workload of quay operation is different in each hour and each day, the quota could be expanded into the one-week period as illustrated in bellow chart.

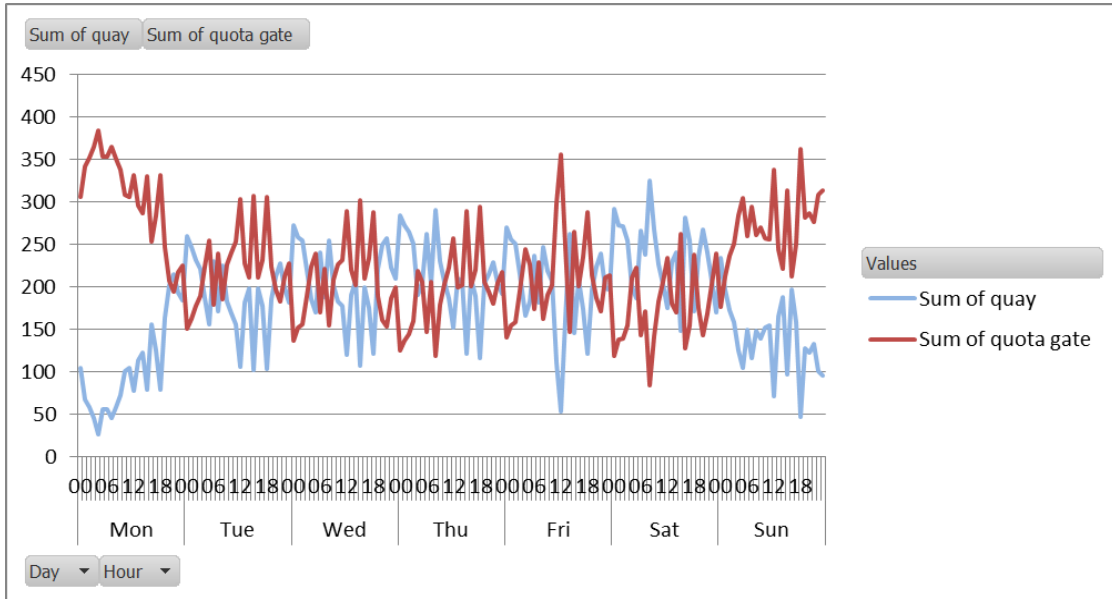


Figure 27 Quay Workload versus Gate Quota

Figure 27 illustrates the quota of gate transaction against quay workload, which represented by a red line and blue line respectively. Both lines are mirroring each other and collectively build an optimum workload for yard operation. When quay workload is high, gate quota will be low, and vice versa.

There are some points where the gap between quay and gate quota is extremely high such as on Monday morning, Friday noon, and Sunday afternoon. The big gap is resulted due to the quay workload is minuscule hence the gate quota becomes huge. Those particular points may not applicable for gate operation due to their business nature. In Monday morning and Sunday afternoon, the trucks do not go to the terminal as the most of factories are still closed. In Friday noon, the gate quota is not applicable due to the terminal is closed for one hour for Friday prayer.

By implementing TAS, workload sourced from gate operation is regulated to balance the workload from quay operation. Hence, the workload of yard operation becomes stable at optimum level 445 moves/hour, as displayed in figure 28.

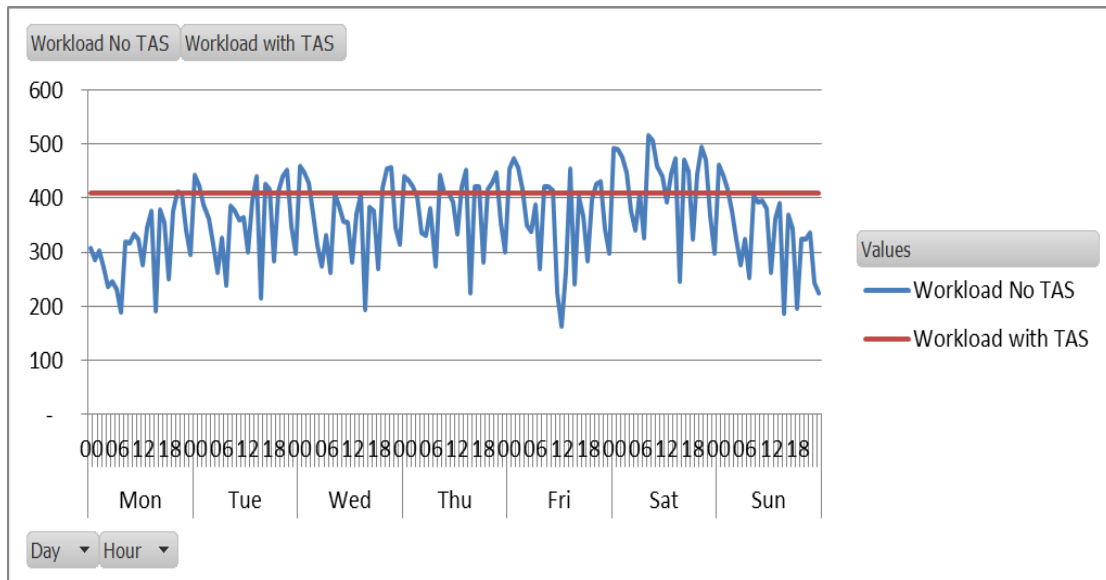


Figure 28 Yard Workload with/without Gate Quota

Figure 28 display how the workloads that exceed optimum level (represented by the blue color above red line) are distributed evenly across the days in a week. Take an example the peak time, on Saturday without TAS workload exceeds the optimum level, as represented by a line above the red line. There are 1153 containers on Saturday that exceed optimum level. By implementation of TAS, the excess workload is distributed to other hours. By moving 1153 containers from Saturday workload to the other days, it will reduce the truck queue significantly.

CHAPTER 6. CONCLUSION and RECOMMENDATION

The simulation and analysis in the previous chapter have proven that capacity limitation of a container terminal could derive from only one operation component that act as the bottleneck of the system. The bottleneck capacity and performance is a binding constraint on the performance of other operation components. Eventually, it impacts the aggregate efficiency of the whole system. In case of JICT yard operation is the bottleneck of the system that limits the entire capacity of the terminal. Even though quay operation and yard operation still have reserved capacity to generate more production, those reserve capacities become idle and unutilized.

Considering yard operation as the critical point, understanding the optimum operational level of yard operation is important in the optimization process. The optimum level of yard operation becomes a benchmark for a terminal manager in managing the whole terminal workload. By understanding the optimum limit of operation, the terminal manager has a standard to assess the achievement of the operation and to make a proper operational decision to respond the condition.

The terminal operation should be managed at an optimum level since working beyond optimum level is not favorable for the terminal. Working under optimum level is a loss as resources become idle. Working over optimum level put the terminal in the risk of over workload situation that may reduce the quality services. The possible way to manage the optimum workload in the terminal with has capacity limitation by controlling the workload sourced from gate operation. The analysis on JICT case where gate operation is not controlled and the trucks can visit terminal without schedule has proven make JICT operation regularly experiences over workload situation. Over workload situation in JICT has triggered congestion during peak time.

To prevent over workload situation and maintain terminal works at an optimum level, TAS is required. By implementation of TAS, truck arrivals can be controlled by setting gate quota in a particular period of services. Gate quota limits the number of trucks that allowed entering the terminal. The simulation has proven that TAS can reduce the congestion during peak time significantly by distributing the excess workload to the other off-peak days. Through the implementation of TAS, the terminal will be able to maintain the operation workload in optimum level which consequently improving the optimization of capacity and equipment.

Implementation of TAS in a container terminal is recommended to improve the quality of planning and optimization process. The success of TAS implementation requires comprehensive plan and preparation for providing reliable and user-friendly ICT system, a simple standard operation procedures, and effective regulation. The most important from all requirement is an acceptance and support from all stakeholders of the container terminal for the implementation of TAS for the benefit of their business.

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Appendices

Appendix-1: Data Daily Equipment Deployment

Daily Equipment Deployment

Day	Values		
	Average of QC_Deployment	Average of RTGC Deployment	Average of FL Deployment
Mon	10	34	2
Tue	8	36	2
Wed	8	37	2
Thu	9	37	2
Fri	9	36	3
Sat	10	38	2
Sun	11	33	3
Grand Total	9	36	2

Appendix-2: Data Hourly Equipment Deployment

Hourly Equipment Deployment

Hour	Values		
	▼ Average of QC_Deployment	Average of RTGC Deployment	Average of FL Deployment
00	9	39	3
01	9	38	3
02	9	37	2
03	9	35	2
04	9	32	2
05	9	33	2
06	8	33	2
07	8	37	2
08	9	38	2
09	9	38	2
10	10	37	2
11	10	35	2
12	10	31	2
13	10	35	3
14	9	35	3
15	8	35	2
16	9	38	3
17	9	38	3
18	10	35	2
19	10	38	3
20	9	38	3
21	9	38	3
22	9	35	2
23	8	38	2
Grand Total	9	36	2

Appendix-3: Data Hourly Equipment Performance

Hourly Equipment Performance

Hour	Values			
	Average of QC Performance	Average of RTGC Performance	Average of FL Performance	Average of Gate Performance
00	22	17	17	41
01	22	17	14	38
02	22	16	14	36
03	20	15	15	33
04	18	13	15	26
05	17	11	14	25
06	17	12	12	34
07	13	13	11	27
08	23	17	13	37
09	23	16	14	31
10	22	16	14	30
11	21	14	13	26
12	19	11	12	18
13	20	15	15	30
14	25	17	17	34
15	12	9	8	19
16	22	16	18	35
17	23	15	15	30
18	17	10	12	18
19	22	16	15	32
20	23	16	15	36
21	23	17	17	37
22	17	12	12	32
23	14	13	13	29
Grand Total	20	14	14	31

Appendix-4: Data Sample Ed and Cm

Data Sample for Ed and Cm

Ed	Cm	Ed	Cm	Ed	Cm	Ed	Cm	Ed	Cm	Ed	Cm
36.52	461.32	38.38	569.12	35.88	450.92	40.50	685.77	36.46	446.08	42.38	736.23
33.76	409.28	35.19	437.19	39.85	537.38	39.54	649.62	38.50	704.00	42.46	697.27
31.24	389.16	35.42	387.12	41.38	743.46	39.27	596.04	38.62	368.35	39.65	432.88
29.24	342.72	35.50	421.46	40.54	639.42	36.04	420.85	40.96	678.27	41.77	673.19
25.68	275.44	39.58	497.77	38.81	599.46	38.77	616.46	41.35	635.27	42.00	685.58
26.44	277.52	40.88	656.81	38.15	571.85	39.08	668.69	38.42	406.42	41.58	686.04
26.44	274.40	39.46	601.62	34.96	393.81	37.35	331.42	41.96	665.62	38.85	449.85
34.60	290.12	38.38	580.65	37.54	593.92	40.81	671.92	41.88	704.31	40.81	517.42
37.48	456.16	37.27	545.42	38.27	621.92	41.04	664.27	41.77	712.85	40.71	620.55
37.68	501.84	34.92	399.69	37.92	314.62	38.15	409.88	39.85	465.08	41.19	684.46
37.32	526.88	37.96	590.38	40.54	614.81	41.46	674.38	42.19	569.15	40.19	632.12
36.72	525.08	37.62	629.62	40.46	590.08	41.54	705.04	38.19	565.40	39.27	574.73
33.72	399.92	36.54	318.88	37.42	394.88	40.85	717.04	42.54	764.92	35.12	491.00
36.60	535.12	40.31	644.31	41.23	663.54	39.31	476.58	42.62	745.62	32.19	398.81
36.20	560.68	41.31	634.23	41.54	708.85	41.19	537.04	41.77	711.04	34.23	378.42
36.68	314.36	38.00	410.81	41.19	723.38	39.65	598.14	40.23	643.00	32.50	371.96
40.36	600.24	40.46	651.73	39.62	484.12	41.88	735.92	37.62	501.04	38.15	428.23
40.72	571.04	41.04	712.92	41.04	569.92	41.46	727.31	37.38	460.50	39.46	617.65
37.92	395.32	40.73	726.12	39.23	578.80	41.23	685.58	37.50	509.62	38.85	613.77
41.16	630.64	38.65	471.19	41.88	751.77	39.23	610.92	41.15	600.04	37.85	595.65
41.64	660.64	41.04	579.27	41.96	731.42	36.23	502.15	42.58	797.38	36.38	563.54
41.20	677.44	38.85	564.76	40.85	681.19	37.27	460.31	41.58	745.96	32.73	378.31
39.32	464.40	42.27	782.77	39.31	618.69	37.46	496.50	41.04	706.27	33.73	488.35
41.64	574.48	41.38	733.58	37.27	490.62	39.12	527.27	40.73	649.12	32.96	507.65
35.85	463.09	40.58	690.77	37.50	464.77	41.54	757.92	38.54	474.73	36.04	286.04
41.88	748.19	38.81	584.38	37.77	490.69	40.88	688.88	41.08	649.50	40.42	598.08
41.54	699.85	35.77	450.92	39.54	550.65	39.73	652.42	40.92	696.88	38.00	520.69
40.42	639.92	36.27	432.46	40.65	750.46	34.77	339.65	40.31	359.23	30.12	287.42
34.04	442.81	34.65	453.88	37.85	377.65	38.34	552.97				
34.88	464.85	28.85	281.15	35.82	476.55						

Appendix 5-JICT Terminal Facilities Equipment & Facility 2012

Description	Terminal I	Terminal II	Total	Remarks
I. Berth				
- Length	1640 M	510 M	2150 M	
- Width	26.5 - 34.9 M	16 M		
- Draught	11 - 14 M	8.6 M		
II. Container Yard				
- Area	45.50 Ha	9.24 Ha	54.74 Ha	
- Capacity	39,884 Teus	7,056 Teus	46.940 Teus	
- Ground Slot				
1. Import	1,027 Teus	104 Teus	1,131 Teus	
2. Export	693 Teus	200 Teus	893 Teus	
3. Reefer				
220 V	-	-	-	
380 V	546 Plug	78 Plug	624 Plug	
III. Equipment				
- Quay Crane Container	16 Unit	3 Unit	19 Unit	
- Rubber Tyred Gantry Crane	63 Unit	11 Unit	74 Unit	
- Head Truck	128 Unit	13 Unit	141 Unit	
- Chassis / Trailers	128 Unit	21 Unit	149 Unit	
- Forklif Diesel	15 Unit	6 Unit	21 Unit	
- Reach Stacker	4 Unit	1 Unit	5 Unit	
- Side Loader	6 Unit	-	6 Unit	
IV. Number of Berth	7	2	9	